A review of the *Onthophagus posticus*-group (Coleoptera: Scarabaeidae: Scarabaeinae) of Australian dung beetles with five new species.

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ABSTRACT

Five new species of the scarabaeine dung beetle genus *Onthophagus* Latreille 1802, are described in the *Onthophagus posticus*-group, from Queensland and New South Wales, Australia: *O. dryander* sp. nov., *O. leichhardti* sp. nov., *O. murgon* sp. nov., *O. penedwardsae* sp. nov. and *O. toopi* sp. nov. New distribution information is given for the other members the species group and the ranges of all species are mapped. A revised key is given to the twelve species now known in the species group. ❐ *Onthophagus posticus, dung beetles, new species, Australia.*

The cosmopolitan dung beetle genus *Onthophagus* Latreille, 1802 is one of the largest genera of animals with in excess of 2300 described species. Understanding its phylogeny and application of that to its taxonomic classification is a major challenge being undertaken by global studies based on both morphology and molecules (Emlen *et al.* 2005; Monaghan *et al.* 2007; Tarasov & Solodovnikov 2011). Preliminary outcomes indicate that much of the Australian fauna may be a monophyletic radiation, though few Australian species have been included in analyses.

The Australian species were comprehensively revised by Matthews (1972) who erected a series of 24 defined species groups as a means of dealing with the diversity. These groups were inherently artificial as they applied only to the Australian fauna but had great practical value, especially for identification purposes, and the system was followed by subsequent authors who have described additional species of Australian *Onthophagus* (Storey 1977; Storey & Weir 1990). The fauna was catalogued by Cassis & Weir (1992) and updated in the Australian Faunal Directory on line (AFD 2013). Currently there are 198 species of *Onthophagus* in the literature from Australia. Of these, 192 are native species, two of which are not recognisable in the absence of specimens and were treated as 'nomina inquirenda' by Matthews (1972), *viz O. granum* Lansberge 1885 and *O. crotchi* Harold 1871. The other six are introduced species: one is a global 'tramp' which entered Australia prior to 1900 (*O. depressus* Harold 1871; Matthews 1972) and the other five are African species introduced intentionally to facilitate cattle dung removal (*O. binodis* Thunberg 1818, *O. nigriventris* d'Orbigny 1902, *O. obliquus* (Olivier 1789), *O. sagittarius* (Fabricius 1781) and *O. taurus* (Schreber 1759) (Anon. 2008). Another African

introduction, usually ascribed to *Onthophagus* in non-taxonomic literature, is more properly referred to as *Digitonthophagus gazella* (Fabricius 1787) (AFD 2013).

Intensive surveying of dung beetles in Australia in the last thirty years has revealed many additional undescribed species of *Onthophagus*. This paper deals with Matthews' *posticus*-group and describes five new species within the taxonomic structure of the genus established by him. The group is confined to Tasmania and the moister parts of eastern Australia, extending inland to a maximum of 370 km from the coast (Fig 8). The greatest diversity is in southeast Queensland which has five species.

STUDY MATERIAL

Specimens are lodged in the Queensland Museum, Brisbane (QM), the Queensland Department of Agriculture, Forestry and Fisheries, Brisbane (QDPC), the Australian National Insect Collection, CSIRO, Canberra (ANIC), the Australian Museum, Sydney (AM) and the Museum of Victoria, Melbourne (MV). All specimens previously published as being in the University of Queensland Collection (UQIC) have now been merged with QM. Label data for holotypes is cited in full but for other specimens abbreviations of some common collector names are used: G.B. Monteith (GBM), D.J. Cook (DJC). Other abbreviations used include New South Wales (NSW), Queensland (Qld), National Park (NP), State forest (SF), Environmental Park (EP), flight intercept trap (FIT). About 4500 specimens have been available in total, and study has been facilitated by access to databases of the relevant museum collections which were validated by GBM during visits to the museums on behalf of the ANHAT (Australian National Heritage Assessment Tool) project of the then Commonwealth Department of Environment, Water, Heritage and the Arts in 2007/08. All specimens are listed for the new species but it is impractical to list the copious new specimen data for described species. Only important records from specific localities are mentioned for these species in the text, but all museum records contribute to the distribution maps in Figure 8. Additional Queensland map distribution points are derived from unpublished survey collections made in recent years at Lamington NP (G.B.M. & Rosa Menendez), Beechmont Plateau (G.B.M. & Susan Cully), Moggill Creek (G.B.M. & Tania Kenyon) and Thiaki Creek (G.B.M., Rosa Menendez & Tania Kenyon), some points from which are not vouchered by museum specimens.

GBM and T.A. Weir have devised an informal code number system for known undescribed species of Australian dung beetles (e.g. *Onthophagus CQ6*) and these are used in Australian museum databases and in some publications. The previous code name is given with the description of each of the new species.

SYSTEMATIC TREATMENT

Onthophagus Latreille, 1802

Onthophagus posticus-group

Mathews' (1972) definition of the *posticus*-group, in which he recognised seven species, is modified below to incorporate the five additional species treated in this paper. All twelve species now recognised run to the *posticus*-group in Matthews' key to his Australian species groups. Information derived from Matthews' key, from the key to species presented in the current paper, and from the revised species-group definition given below should be taken as adding to the diagnosis of the new species described in this paper.

Description. Total length 4–8 mm. Eyes strongly to moderately narrow, with 4–9 facet rows across at the widest point, separated by 8–18 eye widths, canthus incomplete or just touching the occipital edge. Head upper surface glabrous except for row of short setae parallel to clypeal margin. Labium variably excised, from shallowly to almost half way to base. Pronotum glabrous, smooth. Elytra always with discal portion of intervals 1–6 glabrous, entirely glabrous in *O. arrilla*, *O. leichhardti*, *O. murgon*, *O. millamilla* and most *O. turrbal*.

Male with frontoclypeal suture always effaced, vertex unarmed, or with a small conical tubercle near each eye (*O. arrilla*, *O. penedwardsae*, *O. posticus* and *O. mulgravei*), or a low swelling between the eyes which is sometimes sub-carinate (*O. leichhardti*, *O. yackatoon*, *O. penedwardsae* and minor *O. posticus*). Pronotum unsculptured or with a small median, anterior swelling in major males. Fore tibiae elongated and narrowed, with a distal brush of long setae in a cylindrical curved pencil arising from the inner apex (setae more dispersed in *O. toopi*, *O. dryander* and *O. yackatoon*). Inner apical angle of tibia pointed and bent down.

Female without modified forelegs, with frontoclypeal suture present at centre and vertex unarmed except *O. posticus*, *O. leichhardti* and *O. yackatoon* which have a transverse swelling, faint in the last.

CHECKLIST OF SPECIES

XIX. *POSTICUS-group*

1. *Onthophagus arrilla* Matthews, 1972
2. *Onthophagus dryander* sp. nov. (CQ11)
3. *Onthophagus incornutus* Macleay, 1871
   - *Onthophagus semihirtus* Frey, 1963
4. *Onthophagus leichhardti* sp. nov. (CQ3 & NSW3)
5. *Onthophagus millamilla* Matthews, 1972
6. *Onthophagus mulgravei* Paulian, 1937
7. *Onthophagus murgon* sp. nov. (CQ7)
8. *Onthophagus penedwardsae* sp. nov. (NQ12)
9. *Onthophagus posticus* Erichson, 1842
   - *Onthophagus flavolineatus* Blanchard, 1853
   - *Onthophagus leechi* Frey, 1959
10. *Onthophagus toopi* sp. nov. (CQ6)
11. *Onthophagus turrbal* Matthews, 1972
12. *Onthophagus yackatoon* Storey & Weir, 1990

KEY TO SPECIES OF THE *ONTHOPHAGUS POSTICUS* SPECIES GROUP

1. Pygidium and elytra glabrous. 2
   - Pygidium setose; elytra often with setae on at least interval 8 3
2. Black with a red or orange humeral patch on each elytron; frons and clypeus of male smooth, minutely and sparsely punctate; clypeal suture of female evenly curved, continuous (Bulburin to SE Qld, NE NSW) . . . . . *arrilla* Matthews
   - Uniformly black; both sexes with clypeus rugose-punctate and frons coarsely punctate; clypeal suture of female with centre straight, not joining genal sections (inland NSW and S Qld). . . . . *leichhardti* sp. nov.
3. Elytra with setae along full length of interval 8, and often on apices of other intervals 4
   - Elytra usually glabrous, at most with scattered setae along anterior half of interval 8 9
4. Male with a small conical tubercle on vertex on the inner side of each eye.. 5
   - Male without conical tubercles on head . 7
5. Setae extending full length of interval 7; pronotum with coarse punctures separated by width of one puncture; male pronotum sometimes with a low median swelling at front margin; body and legs uniformly black (inland N Qld) . . . . . *penedwardsae* sp. nov.
   - If setae present on interval 7, they are only on posterior half; pronotal punctures finer, usually separated by more than one diameter; male pronotum without anterior, median swelling; often with paler patches on elytra, pronotum, pygidium, underside and/or legs; usually with a greenish tinge 6
6. Pronotal punctures larger, separated by 1–2 diameters; colour variable, often with pale margins to the pronotum, pale longitudinal bars at base and apex of elytra, pale pygidium, and pale legs and venter; each elytron often with a circular deposit in centre (NE Qld to tip of Cape York) . . . . . *mulgravei* Paulian
   - Pronotal punctures very small, separated by many diameters; body dark with greenish tinge, occasionally with vague pale areas at base and apex of elytra; never with deposits on elytra (NE NSW, S Qld and high altitude in N Qld) . . . . . *incornutus* Macleay
7. Surfaces of head, pronotum, elytra and

pygidium nitid, shining black, without trace of shagreening; setae on pygidium long, white, straight and pointing downwards, distributed over whole surface (central coastal Qld) ..... *dryander* sp. nov.

– Surface of at least pygidium shagreened, dull; setae on pygidium erect, curled, pale brown, sparsely distributed on sides only 8

8. Surface of pronotum and elytra shagreened; no transverse carina between eyes; colour black with orange humeral patches on elytra (central coastal Qld). . . *toopi* sp. nov.

– Surface of pronotum and elytra nitid; a low carina between eyes, more pronounced in male; colour uniformly black (inland N NSW) ..... *yackatoon* Storey & Weir

9. Male with a median, anterior swelling on the pronotum; minor male and female with transverse carina on vertex; even numbered intervals of elytra usually pale giving elytra a striped appearance; scattered setae on anterior part of interval 8 (Tas, Vic, SE SA) ..... *posticus* Erichson

– Both sexes with pronotum evenly convex; without transverse carina on head; elytra never striped in appearance; usually without setae on interval 8. 10

10. Size smaller, less than 4.5 mm in length; eyes very narrow, almost linear, 4–5 facets in width, separated by 12–15 eye widths; colour polymorphic in both sexes, may be uniformly black, or black with orange humeral spots, or black with basal and apical bands of elytra and pronotal margins orange; without setae on interval 8 (inland S Qld.) ..... *murgoni* sp. nov

– Size larger, usually more that 6 mm in length; eyes wider, oval, 7–8 facets in width, separated by 9–10 eye widths; colour usually uniformly dark, often with green tinge, occasionally with indistinct pale patches on humeri and elytral apices; sometimes (in some *O. turrbal* populations with setae on anterior part of interval 8) 11

11. Male genitalia as in Fig 7D, with apices of parameres not strongly deflexed against phallobase; never with setae on interval 8; often with greenish tinge; rarely highly shagreened; restricted to rainforested mountains in NE Qld between 16°S and 18.5°S. ..... *millamilla* Matthews

– Male genitalia as in Fig 7E, with apices of parameres deflexed to almost contact phallobase; rarely with greenish tinge; often highly shagreemed; restricted to rainforests of N NSW and SE Qld between 26.5°S and 29.0°S. ..... *turrbal* Matthews

Females and very minor males will not be differentiated at Couplet 4 in the above key. Running them through both halves of that couplet and checking against distribution and figures should achieve a correct identification.

Onthophagus arrilla Matthews, 1972
(Figs 1A, 7A, 8)

Distribution (Fig. 8). This distinctive rainforest species (Fig 1A) was described from Mt Tamborine, Murwillumbah and Woodenbong (Matthews 1972). Williams & Williams (1983a, b, 1984) and Williams (1993, 2002) recorded if from several coastal NSW localities as far south as Buladelah. Storey (1974) recorded it from Victoria Park near Lismore in NSW and from Bulburin SF, Qld. It is now known from about 450 specimens in AM, ANIC, QM and QDPC from 169 localities over a 950 km north/south range, never far from the coast. Significant new records from NSW include Wishing Well Forest Park (33°06'S, 151°23'E), Bellingen River, Boundary Creek SF, Ewingar SF and Beaury SF (all AM). In Queensland numerous QM records show it occurs in the Border Ranges from Tallebudgera west to Wilson's Peak, in the western suburbs of Brisbane, and in the D'Aguilar, Conondale, Jimna and Blackall Ranges, and in lowlands to as far north as Tinana Creek at Maryborough. There is a disjunction of 160 km in its distribution between Tinana Creek and the outlying, northern, upland population at Bulburin. Aedeagus as in Fig 7A.

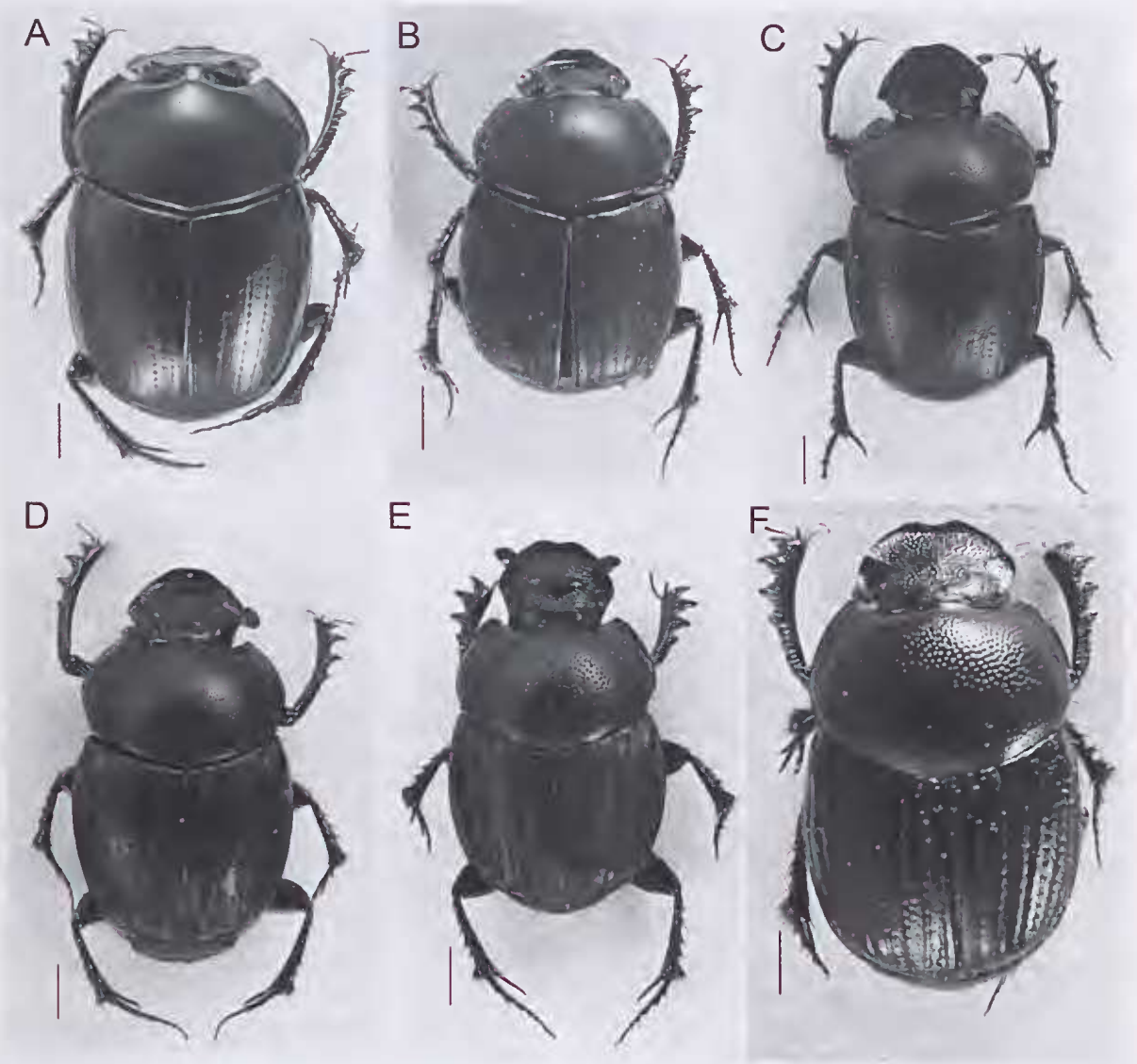

FIG. 1. The described species of the *Onthophagus posticus* group. **A**, *Onthophagus arrilla* Matthews, male; **B**, *O. incornutus* Macleay, male; **C**, *O. millamilla* Matthews, male; **D**, *O. mulgravei* Paulian, male; **E**, *O. posticus* Erichson, female; **F**, *O. yackatoon* Storey & Weir, male. Scale lines 1 mm.

Onthophagus dryander sp. nov.
(Fig. 2, 7B, 8)

Etymology. Named for the mountain, just east of the town of Proserpine, on which it was collected.

Material examined. HOLOTYPE: ♂, C.Qld: 20°15'S x 148°33'E, Mt Dryander, 650 m, 21 Nov 92 – mid Apr 1993, D. Cook & G.B. Monteith, RF (rainforest) intercept and pitfalls (in QM, QMT156620). PARATYPES: 3♀, same data as holotype (in QM, QMT156617–156618).

Description. Upperside, underside and legs nitid, shining black except for reddish-orange bases of elytral intervals 2, 4,6 and 7, those of 6 and 7 coalescing to form an oval humeral spot on each side. Two females with more extensive reddish colouration across the base and apex

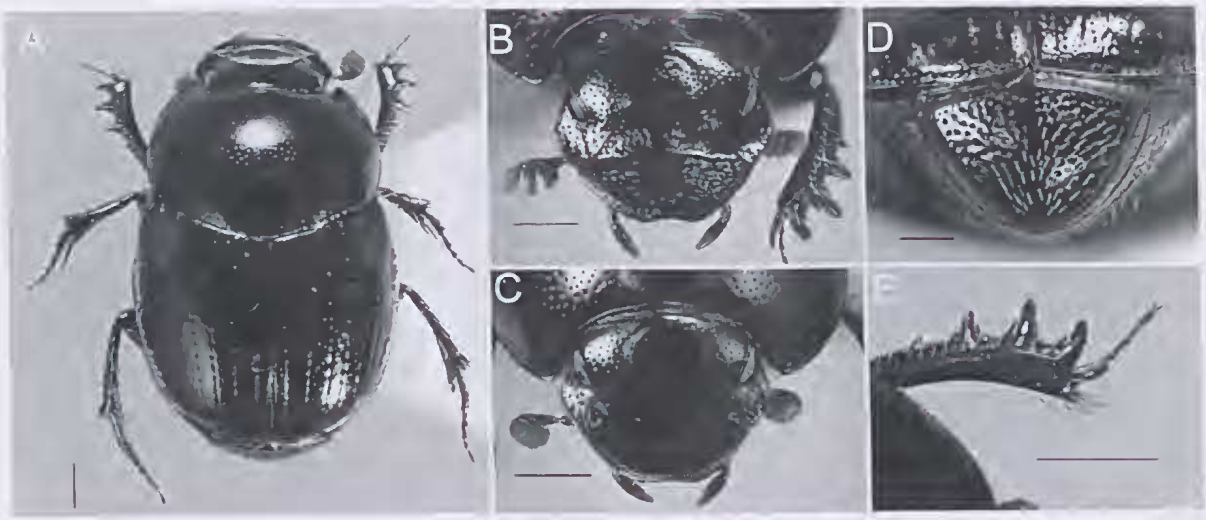

FIG. 2. *Onthophagus dryander* sp. nov. **A**, male, dorsal view; **B**, female, head and fore tibia; **C**, male, head; **D**, male, pygidium; **E**, male, fore tibia. Scale lines 0.5 mm.

of elytra. Antennal clubs fuscous. Total length 4.0–4.9 mm.

Male. ***Head.*** Clypeal margin medially weakly bilobed, rest of margin straight until genal angles, which are obtusely rounded. Clypeal suture with frontal section entirely effaced. Frons flat, without elevations. Eyes very narrow, 5 facet rows in width, separated by 16 eye widths, canthus incomplete but almost closed. Surface smooth, nitid, with very fine punctures evenly and sparsely scattered over entire surface, glabrous.

Pronotum. Evenly, feebly convex, unsculptured. Anterior angles subacute, apices angulate. All edges with narrow marginal bead. Surface smooth, glabrous, nitid; punctures very small, scattered evenly over entire surface, separated by 6–7 diameters.

Elytra. Intervals flat, smooth, nitid, with scattered small punctures. Striae nitid with small regular punctures. Numerous straight, white, pointed setae present along entire length of last interval, all recumbent obliquely upwards.

Legs. Fore tibiae slightly elongated and narrowed, inner apical angle acute and bent downwards, bearing a sparse tuft of long curved setae about 1.5 times length of spur, which extends slightly down the inner shaft of the tibia. Spur shortened, curved downwards.

Abdomen. Pygidium convex, nitid, uniformly covered with moderate punctures, each bearing a straight, white, pointed, recumbent seta directed obliquely downwards. Aedeagus as in Fig. 7B.

Female. Clypeal suture complete, uniformly weakly curved, carinate in central four fifths. Clypeal surface strongly transversely rugose. Frons with weak, central, triangular impression. Pronotal surface nitid. Fore tibiae unmodified. Otherwise like male.

Comments. Known only from a small series from long-term unbaited trap collections in rainforest slightly below the summit of 775 m high Mt Dryander, close to the coast and forming a northern extension of the Conway Range (Fig. 8). Its shiny colours and small eyes indicate it is probably a diurnal species. Its closest relative seems to be *O. toopi*, another localised rainforest species from 400 km to the south. Both are small, setose, coloured species with the male fore tibial brush composed of dispersed setae instead of a tight cylindrical pencil. *Onthophagus dryander* has been referred by the code name *Onthophagus* CQ11.

Onthophagus incornutus MacLeay, 1871
(Figs 1B, 7C, 8)

Distribution (Fig. 8). Since Matthew's 1972 distribution map, extra records have been published from coastal NSW by Williams & Williams (1983c) and Williams (1993, 2003) while Storey (1973 a, b) recorded it from Bald Mountain and Inglewood in Qld. Queensland sites where it was taken during a survey of pasture dung beetles in 2001–2002 are mapped by Edwards (2003). Emberson & Matthews (1973) noted its accidental introduction to New Zealand. This is one of the commonest dung beetles in eastern Australia (Fig 1B) and almost 1500 specimens are available from 16 localities in eastern New South Wales, 291 localities in southern Queensland and 26 localities within an isolated montane population in the Qld Wet Tropics, over a north/south range of 2100 km. Within NSW its southern limit is extended to the Illawarra region, south of Sydney (Mt Keira, QM) and its western limit to Reedy Creek and Ramornie SF (AM). In Qld the southern population is common in suburban Brisbane and extends west to central highlands of Carnarvon NP and north almost to Mackay (QM). Most of the inland occurrences in Qld are in vine scrubs.

Matthew (1972) discusses geographic overlap and colour pattern intergrading with its close relative, *O. mulgravei*, at the northern end of the Atherton Tableland in the Wet Tropics. This region has now been intensively surveyed for many years. *Onthophagus incornutus* has a relictual pattern in high altitude open forests along the western fringe of the mountain systems (Ravenshoe, Millstrean Falls, Tumoulin, Wondecla, Walsh Range, Tinaroo, Atherton, W of Julatten, Windsor Tableland, QM & ANIC), while *O. mulgravei* extends up from the lowlands to occupy the lower and drier rainforests of the northern Atherton Tableland (Kuranda, Wongabel, Tolga, Gillies Highway, QM, QDPC, ANIC). Neither species occurs in the wetter, higher rainforests of the southern Tableland where their place is taken by congener *O. millamilla*. Some specimens of *O. incornutus* from open forests at Tinaroo and Yungaburra have incipient *mulgravei*-type colour patterns, but are distinguishable by their small pronotal punctures. The apparent genetic tension between the two species in this area, where they are closely contiguous in different habitats, is probably related to that described in the same general area between species pairs of *Temnoplectron* as a result of temporal fluidity of the Black Mountain biogeographic barrier (Reid & Storey 2000; Bell *et al.* 2003). Aedeagus shown in Fig. 7C.

Onthophagus leichhardti sp. nov.
(Figs 3, 7D, 8)

Etymology. Named for the daring and erudite explorer, Ludwig Leichhardt, in the 200th anniversary of his birth. His route in mid-November 1844 (Fig.8) passed through the western limit of the range of this species, just north of the present township of Taroom. Perhaps the species feasted on his leavings. Leichhardt battled to get his men, horses and bullocks through the dense brigalow scrubs and prickly vine forests which form the habitat of this species. Sadly, today they are mostly gone.

Material examined. HOLOTYPE: ♂, QLD: 26°04'S, 150°49'S, "Wonga Hills", site 2, 4-5Mar2002, dung trap, Monteith & Cook, vine scrub, 500 m (in QM, QMT109042). PARATYPES (139): 9♂ 9♀, same data (2♂ 2♀ in ANIC; 1♂ 1♀ in QDPC; 1♂ 1♀ in AM; 5♂ 5♀ in QM, QMT109043-52); 4♂ 8♀, same data but 11-12 Dec 2001 (in QM, QMT107815-19, 109015-21); 1♀, QLD: 26°04'S, 150°50'S, "Wonga Hills", site 3, 520 m, vine scrub, 11Dec 2001-4Mar2002, GBM & DJC, FIT (in QM, QMT109022); 1♂, QLD: 26°03'S, 150°50'S, "Wonga Hills", site 4, 470 m, brigalow, 11-12Dec2001, GBM, dung trap (in QM, QMT107820); 1♂, QLD:26°06'S, 150°48'S, "Wonga Hills", site 6, 430 m, 4Mar2002, GBM & Wright; 2♂ 3♀, same locality, 4-5Mar2002, GBM & DJC, dung trap, vine scrub (in QM, QMT109055-59); 1♂, QLD, 26°03'S, 151°06'S, Allies Creek, 5 km N., 360 m, vine scrub, 11Dec2001-4Mar2002, GBM & DJC, FIT (in QM, QMT109122); 1♀, same locality, 4Mar2002, S.G. Wright, ex cow dung (in QM, QMT107822); 5♂ 1♀, 25°34'S 151°42'E, Wetheron, 3 km SW, vine scrub, 150 m 27-28Jan1999, DJC, dung pitfall (in QM, QMT99943-48); 8♂, 9♀, 25°40'S, 151°26'E, Nipping Gully, Site 2, 200 m, rainforest, 18-19Dec1998, GBM, dung trap (in QM, QMT99957-73); 6♂, 4♀, same locality, 300 m, 18Dec1998-25Jan1999, GBM & C. Gough, pitfall (in QM, QMT99976-86); 4♂ 4♀, same locality, 25-27Jan1999, GBM, dung pitfall (in QM, QMT99949-56); 1♂, 25°41'S, 151°25'E, Nipping Gully, Site 3, 240 m, open for., 26Jan-2Jun1999, GBM & Thompson, pitfall (in QM, QMT99941); 2♂, 25°42'S, 151°26'E, Nipping Gully, Site 5, 200 m, rainforest, GBM, dung trap (in QM, QMT99974-75); 1♂, 25°38'S, 151°36'E, Gayndah,

hospital hill, scrub rem., 120 m, 25Jan-2Jun1999, GBM & Thompson, pitfall (in QM, QMT99942); 1♂, 25.59°S,149.77°E, Taroom, 5 km N, 15-16.xii.2000, GBM & DJC (in QM, QMT104995); 9♂ 11♀, 24°49'S 149°45'E, Brigalow Res. Stn., Site 2, vine scrub, 170 m, 16-17Dec2000, DJC & GBM, dung pitfall (in QM, QMT104975-94);2♂, same locality, 16Dec2000-28Mar2001, DJC & GBM, FIT (in QM, QMT104996-97); 2♂ 4♀, same data but 28Oct-16Dec2000 (in QM, QMT104999-5003); 10♂ 4♀, 25°29'S 151°26'E, Gurgeena Plateau, Site 5, vine scrub, 320 m, GBM & DJC, 14-15Oct2001, dung trap (in QM, QMT107801-14); 3♂ 4♀, 26°13'S, 150°35'E, Barakula, 23 km ENE, 400 m, brigalow scrub, GBM & DJC, FIT trap (in QM, QMT109023-29); 1♂ 5♀, same data but pitfall trap (in QM, QMT109030-35).

Other Material. 1♂, NSW, 31°35'21"S, 147°36'52"E *E. populnea* patch, 23.6 km NW from Warren on road to Canoba, 22 Nov 1999 – 12 Dec 1999, L. Wilkie, J. Tarnawski, H. Doherty, H. Smith, DRRP054/03 pit trap (ANIC); 3♂, NSW, farm 606, Coleambally Irrigation Area, 34°58'03"S, 146°00'45" E, 2-16 May 2004, L. Wilkie & M. Elliot, COLL002/03 pit trap (AM); 1♂, same locality but 35°01'59"S, 145°55'04" E, 14 Dec 1998, L. Wilkie & S. Priday, COLL004/02 (ANIC).

Description. Dorsal surface black, antennal clubs fuscous. Total length 5.0–6.4 mm.

Male. ***Head.*** Clypeal margin emarginate in middle, rest of margin feebly rounded to genal angles, which are angulate. Clypeal suture with frontal section effaced, genal sections finely carinate. Vertex with broad v-shaped subcarinate swelling between eyes, effaced in centre. Eyes moderate with 7–8 facet rows across widest point, separated by about 9 eye widths, canthus incomplete. Clypeal surface transversely rugose, strongly punctate, frons not rugose, punctures smaller. Fronto-clypeus with slight swelling in centre. Surface nitid, some shagreening along posterior margin of head, glabrous except row of setae behind anterior margin of clypeus.

Pronotum. Feebly, evenly convex, unsculptured. Anterior angles subquadrate, posterior edge unmargined. Disc evenly punctate with small punctures, separated by about 1–2 diameters, finely shagreened, more nitid in centre, glabrous.

Elytra. Intervals feebly convex, weakly shagreened to subnitid, with scattered fine punctures, glabrous. Striae shallow, simple with small regular punctures crenulating edges of intervals.

Legs. Fore tibia elongate, narrowed with inner apical pencil-like, curved brush of dense setae as long as fore tarsi, apical spur shortened, downturned at apex, inner tibial apex acute, turned downwards.

Abdomen. Pygidium feebly convex, evenly punctate with shallow punctures separated by about 1 diameter, shagreened, glabrous. Aedeagus as in Fig. 7D.

Female. Clypeal suture with frontal section straight, carinate, not joined to genal sections. V-shaped subcarinate swelling on vertex less developed. Fronto-clypeus without central swelling. Elytral intervals more distinctly shagreened. Fore tibiae unmodified. Otherwise like male.

Distribution (Fig. 8). The species is abundant in vine scrubs and brigalow scrubs around Gayndah and west to Theodore, Taroom and Barakula in inland southern Queensland. Its range within Queensland occupies a diameter of about 200 km. All specimens were trapped using dung baited pitfall traps or unbaited flight intercept traps. A few specimens of this species are available from two well separated sites much further south, west of the Great Dividing Range in New South Wales (near Warren and Coleambally). These sites are in open eucalypt forest which indicates the species may be much more widespread in NSW.

Comments. *Onthophagus leichhardti* sp. nov. looks superficially like *O. frenchi* Blackburn in the *mutatus*-group, from the same general region, but the elongated and tufted male tibiae refer it to the *posticus*-group. Like *O. arrilla*, it is unusual within the *posticus*-group in being completely glabrous on all dorsal surfaces including the pygidium. Queensland populations have been referred to by the code name of *Onthophagus CQ3* and those in New South Wales by *O. NSW3*.

Onthophagus millamilla Matthews, 1972
(Figs 1C, 7E, 8)

Comments. Matthews (1972) described *Onthophagus millamilla* and *O. turrbal* on consecutive pages, stating they were closely related.

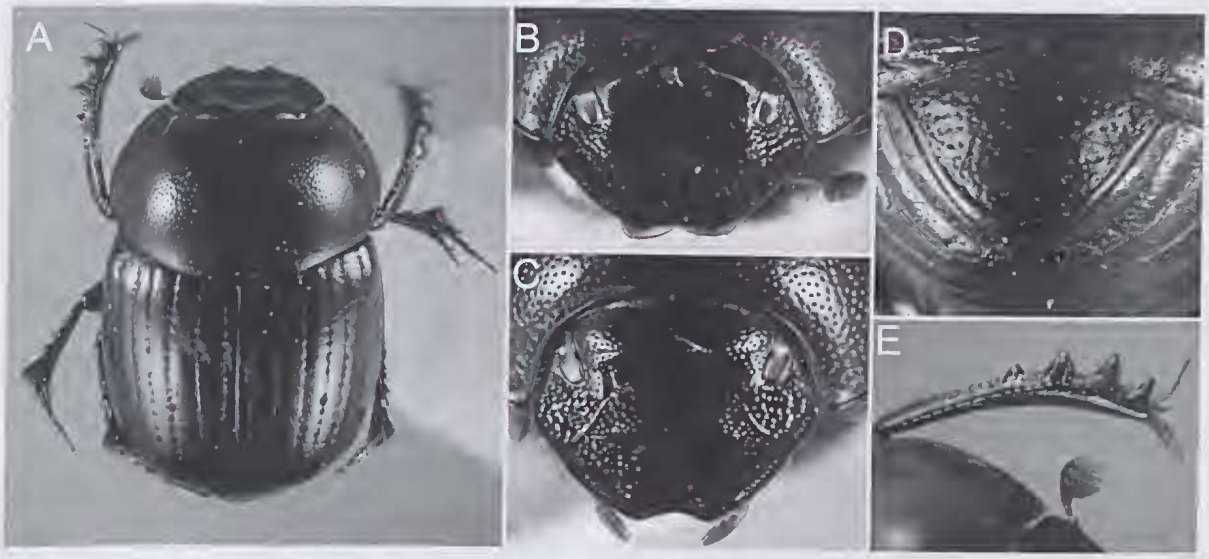

FIG. 3. *Onthophagus leichhardti* sp. nov. **A**, male, dorsal view; **B**, male, head; **C**, female, head; **D**, male, pygidium; **E**, male, fore tibia.

At that time *O. millamilla* was known from 10 specimens from two localities on the Atherton Tableland and four specimens from one locality 1300 km further south (Mt Glorious). The southern specimens had greenish tints and pale humeral spots, as in some of the northern specimens, but they also had setae on the anterior of interval 8 not seen in northern examples. On balance he merged them all as one species. From another locality a little further south (Mt Tamborine), he had a series of similar specimens which lacked the setae, the greenish tint and the humeral spots and these were described as *O. turrbal*. We now have more than 1000 specimens of these two putative taxa from 107 localities over a 300 km range in north Queensland and from 74 localities over a 270 km range in south-eastern Queensland and north-eastern NSW. These show that, within S Qld and NE NSW, these minor characters vary from population to population, though an overall unity persists. The presence of setae on interval 8 which Matthews noted at Mt Glorious also occurs uniformly at Mt Mee, occasionally in the Blackall Range, rarely in the Jimna and Conondale Ranges and never in populations south of Brisbane. Greenish tints and humeral spots occur occasionally north of Brisbane but also to the south. More southerly populations (Lamington and Nightcap Range) tend to be smaller and more strongly shagreened. However male genitalia are uniform throughout the southern populations (Fig. 7K). Similarly, north Queensland populations are much more extensive than the single locality known to Matthews and spread across several mountain systems on both sides of the Black Mountain Biogeographic Barrier, with some morphological variation. All NQ populations have consistent male genitalia (Fig. 7E) which are different to the southern form. All populations are largely confined to rainforested plateaus and fairly clearly represent fragments of more continuous taxa which have been isolated through drying climates forcing rainforests upslope and the erosional dissection of formerly much larger plateau systems. Taking the great geographic separation of the two distinct genitalia types into account we treat here all northern populations as *O. millamilla* and all southern populations as *O. turrbal*.

Distribution (Fig. 8). Since being mapped by Matthews (1972), Brooks (1974) recorded the northern population from Boar Pocket and Monteith (1986) recorded it above 500 m in an altitudinal transect study at Cape Tribulation The north Queensland population occurs above

about 500 m on all rainforested mountains from Cardwell Range north to Mt Williams, and then again from Mt Lewis north to the mountains behind Cape Tribulation (all QM). *Onthophagus millamilla* is a dung-feeding rainforest species.

Onthophagus mulgravei Paulian, 1937
(Figs 1D, 7F, 8)

Distribution (Fig. 8). Since Matthews' 1972 distribution map, Howden *et al.* (1991) record the species (fig 1D) from Wongabel SF, Monteith (1986) records it only as high as 200 m in an altitudinal transect study at Cape Tribulation and only as high as 100 m on the Bellenden Ker transect 1981 (Monteith & Davies 1992). We now have about 600 specimens from 125 localities ranging over 1100 km from the tip of Cape York to Wallaman Falls in the Herbert River valley (QM), with a population on Palm Island a little further south (QM). It is primarily a lowland rainforest species and extends to moderate heights on the eastern side of many plateaus adjacent to coastal lowlands. In the Lamb Range it reaches the unusual height of 1000 m on Mt Tiptree (ANIC) and Mt Haig (QM). See discussion of *Onthophagus incornutus* for interaction with that species on the Atherton Tableland. *Onthophagus mulgravei* often has a large patch of grey deposit on middle of each elytron (as mentioned by Matthews 1972) but, when *O. incornutus* very rarely has them, the patches are small. The pronotum is completely dark in populations of *O. mulgravei* at the tip of Cape York and on Palm Island. The aedeagus (Fig 7F) is very similar to that of *O. incornutus*.

Onthophagus murgon sp. nov.
(Figs 4, 7G, 8)

Etymology. Named for the nearby town of Murgon, close to the birthplace of GBM.

Material examined. HOLOTYPE: ♂, SEQ: 26°09'S 151°59'E, Boat Mt, Summit E.P., 26Jan-20Apr1995, G.B. Monteith, vine scrub, intercept trap (in QM, QMT98188). PARATYPES (50): 10♂ 12♀, same data as holotype (7♂ 9♀ in QM, QMT 98189-204; 2♂ 2♀ ANIC; 1♂ 1♀ QDPC); 1♂ 1♀, same locality, 520 m, 3-4Feb2005, DJC, dung trap (in QM, QMT153601-02); 10♂ 15♀, 26°08'S 151°58'E, Jack Smith E.P. on Boat Mountain, 15Dec1994 – 26Jan1995, GBM, vine scrub, FIT (1♂ 1♀ in AM; 9♂ 14♀ in QM, QMT98211-21, 98225-35); 1♂, 26°08'S 151°59'E, Nangur S.F., 2nd Site, 24Nov1995-3Feb1996, GBM, 320 m, rainforest, pitfall traps (in QM, QMT98236).

Description. A polymorphic species with three sympatric colour forms: (1) entirely black, (2) black with a red humeral spot on each elytron covering base of intervals 6, 7 and sometimes 8, (3) black with the following orange marks: a band across the base and apex of the elytra, the basal band widening into humeral spots, wide anterior and lateral margins of pronotum, edges of pygidium. Antennal clubs fuscous. Most dorsal surfaces sericeus, shagreened. Total length 4.1–5.1 mm.

Male. *Head.* Clypeal margin medially emarginate, narrowly reflexed, rest of margin almost straight to genal angles which are broadly angulate. Clypeal suture with frontal section entirely effaced, genal sections very finely carinate. Frons and vertex unsculptured. Surface flat, nitid, glabrous with fine punctures separated by about one diameter, punctures coarser around margins. Eyes very narrow, 5 facet rows in width, separated by 15 eye widths, canthus almost touching occipital edge.

Pronotum. Feebly, evenly convex, unsculptured. Anterior angles angulate. Anterior and posterior beaded margins complete. Surface finely shagreened, numerous small punctures separated by 1–2 diameters, glabrous.

Elytra. Intervals flat to feebly convex, smooth, shagreened, with numerous small punctures, glabrous. Striae shallow, nitid with regular medium punctures slightly crenulating intervals.

Legs. Fore tibiae elongate, slender, inner apical angle bearing a dense tapering pencil of long setae, which are recurved at tip. A shorter looser group of setae located on front margin of apical tooth. Apical spur shortened, bent downwards.

Abdomen. Pygidium feebly convex, shagreened, with shallow medium-sized punctures separated by less than 1 diameter. Surface with short, straight setae located on lateral angles. Aedeagus as in Fig. 7G.

Female. Clypeal suture with frontal section carinate, almost straight to lateral margins of

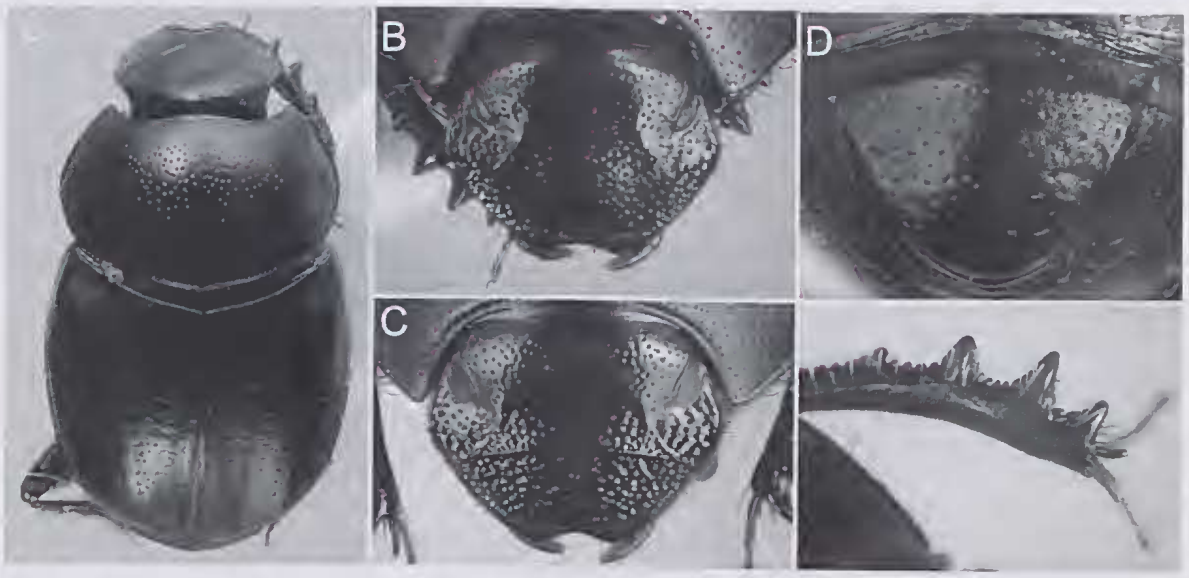

FIG. 4. *Onthophagus murgon* sp. nov. **A**, male, colour form 3, dorsal view; **B**, male, head; **C**, female, head; **D**, male, pygidium; **E**, male, fore tibia.

clypeus. Clypeal surface transversely rugose. Frons and frontal area with punctures stronger than male, separated by less than one diameter. Pronotal punctures slightly coarser. Fore tibiae unmodified. Otherwise like male.

Distribution (Fig. 8). Known only from several patches of remnant vine scrubs on and adjacent to a small volcanic plateau known as Boat Mountain, 10 km north of the township of Murgon in the South Burnett district. Its distribution lies within a diameter of 10 km.

Comments. This small species shares some important features with the much larger *O. turrbal* (glabrous elytra, male forelegs with long curved brushes) and may have arisen as an isolate of that species which comes as close as 40 km distant on the Jimna Ranges. The very narrow eyes of *O. murgon* serve to differentiate it. The breakdown by sex of the colour forms of available specimens is: Form 1 (12♂ 12♀), Form 2 (4♂ 1♀), Form 3 (6♂ 8♀). All specimens were collected by dung baited pitfalls or flight intercept traps. *Onthophagus murgon* has been referred to by the code name of *Onthophagus* CQ7.

Onthophagus penedwardsae sp. nov.
(Figs 5, 7H, 8)

Etymology. The specimens were collected during a 2001/02 survey of pasture dung beetles in Queensland, coordinated by dung beetle ecologist Dr Penelope Edwards, a friend from university days, and we take pleasure in giving her name to the species.

Material examined. HOLOTYPE: ♂, 20°39'16"S, 144°23'39"E, 'Delbessie' 35 km NNE Hughenden, 15.v.2001, G. McNamara, cow dung baited pitfall (in QM, QMT 189740). PARATYPES (83): 7♂ 6♀, same data as holotype (6♂ 5♀ in QM, 1♂ 1♀, QDPC); 1♂ 1♀, 20°39'16"S, 144°23'39"E, 'Delbessie' 35 km NNE Hughenden, 18.iv.2001 G. McNamara, Trap 2: Galah Rd, cow dung baited pitfall (in QM); 2♂ 1♀, 20°39'10"S 144°23'17"E, 'Delbessie' 35 km NNE Hughenden, 20.xi.2001, G. McNamara, Trap 2: Galah Rd, cow dung baited pitfall (QM);1♂ 1♀, same data but 12.vi.2001 (QM);1♂ 4♀, same data but 16.x.2001 (QM); 24♂ 26♀, same data but 15.i.2002 (23♂ 25♀ in QM, 1♂ 1♀ ANIC, 1♂ 1♀ AM); 1♂ 2♀, same data but 18.ii.2002 (in QM); 2♀, same data but 14.iii.2002 (in QM); 1♀, same data but 16.iv.2002 (in QM); 2♀, 20.38.32S 144.20.41E 'Delbessie' 35 km NNE Hughenden, 14.viii.2001, G. McNamara, Trap 1: Crescent Creek, cow dung baited pitfall (QM); 1♀, same data but 15.i.2002 (QM).

Description. Black, nitid, with very slight purplish shine, antennal clubs fuscous. Total length 3.8–5.9 mm.

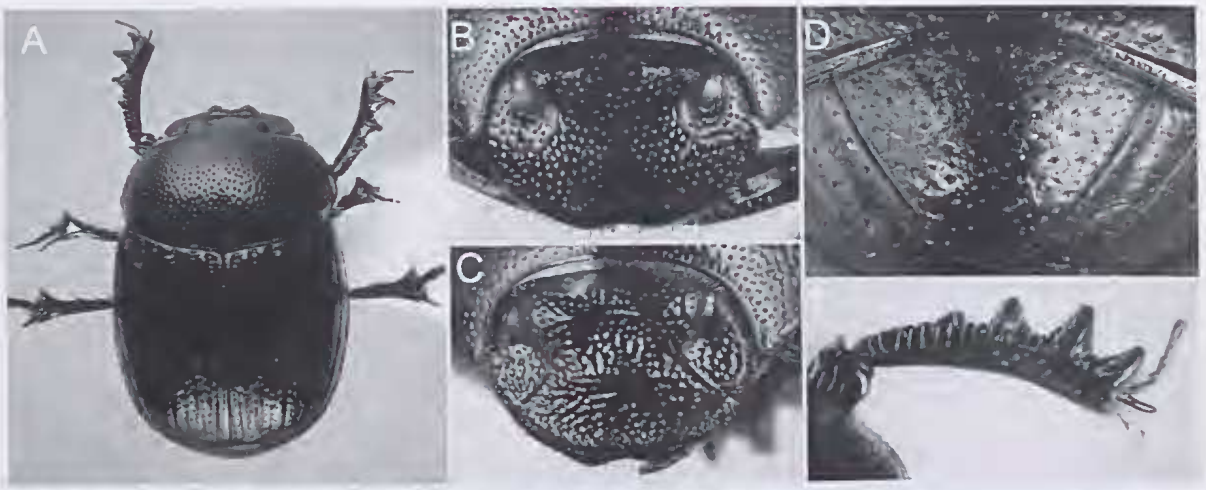

FIG. 5. *Onthophagus penedwardsae* sp. nov. **A**, male, dorsal view; **B**, male, head; **C**, female, head; **D**, male, pygidium; E, male, fore tibia.

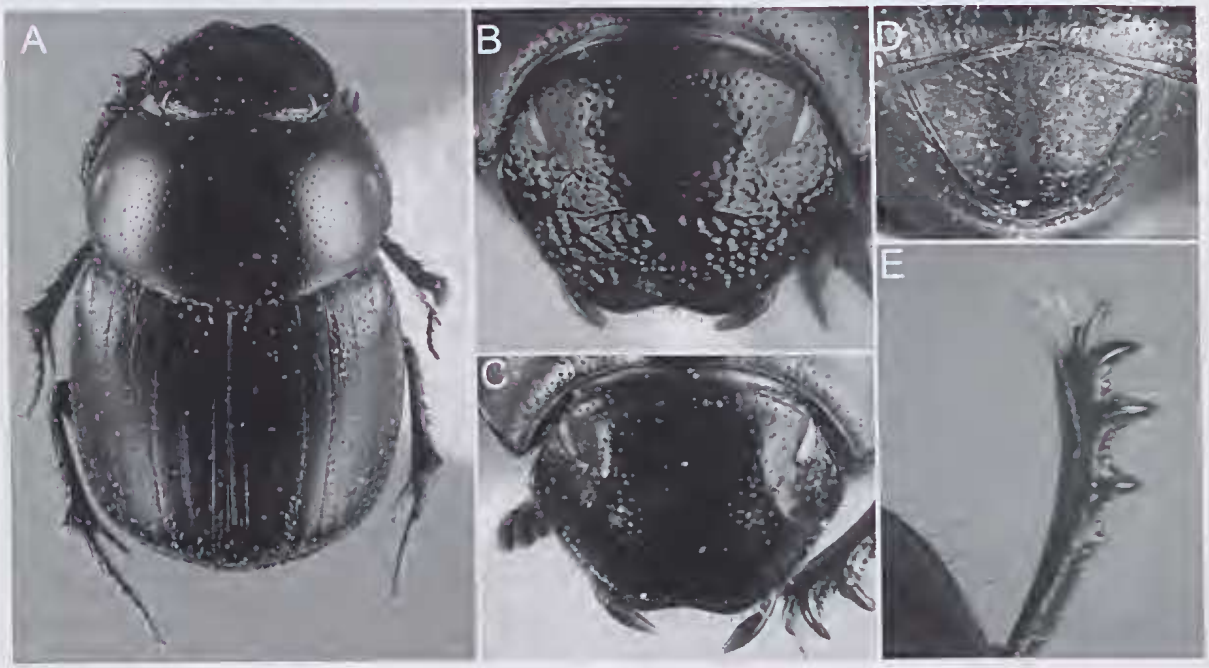

FIG. 6. *Onthophagus toopi* sp. nov. **A**, male, dorsal view; **B**, female, head; **C**, male, head; **D**, male, pygidium; **E**, male, fore tibia.

Male. ***Head.*** Clypeal margin bilobate, lobes closer together and more upturned in major male, rest of margin almost straight to genae which are rounded, genae somewhat depressed anterior to eyes. Central section of fronto-clypeal suture effaced, with slight central tumescence, genal sections distinct. Frons with pair of low blunt protuberances, one mesal to each eye. Eyes moderate, with 7–8 facet rows across widest point, separated by 8 eye widths, canthus incomplete. Surface punctate with small punctures separated by about 1 diameter, nitid, glabrous except for a fringe of close-set setae on a beaded ridge behind anterior margin

of clypeus. Punctures almost effaced in centre of head, stronger on genae.

Pronotum. Feebly convex with slight tumescence at centre of anterior margin in some specimens. Anterior angles subacute. All margins finely beaded. Disc nitid with moderate, impressed punctures, separated by less than one diameter near anterior and lateral margins, a little more widely spaced in centre of disc. Glabrous.

Elytra. Intervals slightly convex, apex of second interval depressed, shagreened along edges, rest of surface nitid with scattered small punctures. Sparse recurved setae along entire length of last interval and at apices of other intervals, sometimes extending forward to half length of intervals 6 and 7. Striae shallow with small regular punctures.

Legs. Protibiae slightly elongate and narrowed, inner apical angle down-turned and with dense brush of long setae, spur shortened.

***Abdo*men.** Pygidium feebly convex, shagreened except near apex, covered with small shallow punctures, separated by 1–2 diameters, each with a short seta except along centre line. Aedeagus as in Fig 7H.

Female. Clypeal lobes less pronounced, less upturned and further apart. Central section of fronto-clypeal suture straight, strongly carinate but not joining oblique genal sections. Pronotum without tumescence on anterior margin. Frons without pair of protuberances, replaced by low subcarinate ridge. Clypeal and frontal punctures coarser, more closely set, surface transversely rugose near anterior margin. Protibiae unmodified. Otherwise like male.

Comments. This species very similar in size, colour and setation to another inland species, *Onthophagus yackatoon*, which occurs 1200 km further south in NSW. However *O. yackatoon* has much narrower eyes, lacks head ornamentation in the male and lacks setae on rear of intervals 2 and 4. The free central portion of the fronto-clypeal suture of female *O. penedwardsae* is also distinctive. It has been referred to as *Onthophagus NQ12* in museum registers and Edwards (2003) maps it as *Onthophagus* sp. nov. 2.

Distribution (Fig. 8). All specimens were taken in traps baited with cow dung at two sites on 'Delbessie' grazing station, NNE of Hughenden. The locality is in semi-arid, sandy alluvial habitat about 15 km S of the Porcupine Gorge NP on the Kennedy Development Road.

Onthophagus posticus Erichson, 1842
(Figs 1E, 7I, 8)

Distribution (Fig. 8). This species (Fig 1E) is comparatively uncommon in collections despite its large size and banded colouration, but 415 specimens are now available from 29 localities in Tasmania, 33 in Victoria and two in South Australia. In Tasmania, it is confined to the drier eastern and northern parts of the island with records now from the NW corner at Woolnorth (ANIC) and King Island (MV). A northern range extension to 45 km S of Bombala (ANIC) places it close to the NSW border. Bornemissza (1983) trapped it with wallaby, wombat, cattle, horse and sheep dung in both Tasmania and eastern Victoria, and speculates that it would have been one of the four dung beetle species that Charles Darwin saw at Hobart in 1836. Faithfull (1992) took it at fox scats in Victoria. The aedeagus is shown in Fig 7I.

Onthophagus toopi sp. nov.
(Figs 6, 7J, 8)

Etymology. This species is named in honour of our good friend, the late John Toop, who died in September 2003, and whose life's passion was the preservation of the limestone karst habitats of the Mt Etna area of central Queensland which form the beetle's sole habitat.

Material examined. HOLOTYPE: ♂, 23°09'S 150°28'E, Johannsens Cave, 18.xii.1999-21.iii.2000, Monteith, vine scrub, intercept, 100 m (in QM, QMT97969).

PARATYPES (38): 6♂ 3♀, same data as holotype (in QM, QMT97960-68); 3♂ 2♀, same data but 7.x-18.xii.1999, DJC & I. Cook (in QM, QMT105351-105355); 1♀, same locality, 14-15 Apr 2010, GBM, dung trap (in QM, QMT178727); 3♂, 23.163°S 150.466°E, Limestone Ridge, Ballroom Track, start, vine scrub, 15 Apr 2010, GBM (in QM, QMT178728-30); 1♀, Capricorn Caves, cabins, 106 m, mowed area, 13-15 Apr 2010, GBM, dung trap (in QM, QMT178726); 15♂ 4♀, Capricorn Caves, RF walk, 100 m, 13-15 Apr 2010, GBM, dung

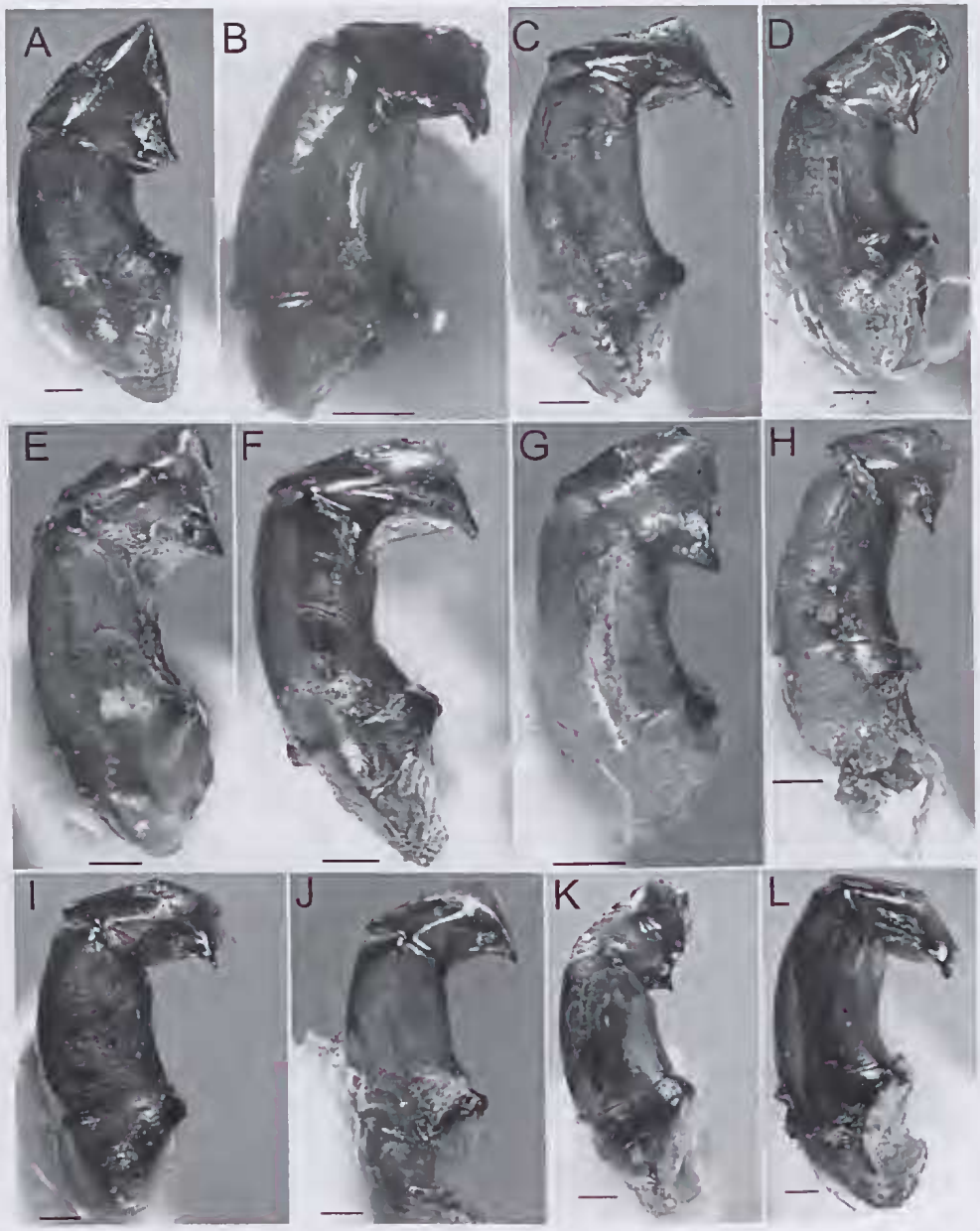

FIG. 7. Genitalia of male *Onthophagus* species. **A**, *O. arrilla* (Beechmont, Qld.); **B**, *O. dryander* (Mt Dryander, Qld); **C**, *O. incornutus* (Gatton, Qld.); **D**, *O. leichhardti* (Gurgeena, Qld.); **E**, *O. millamilla* (Millsteam CP, N. Qld.); **F**, *O. mulgravei* (Kirrama, Qld.); **G**, *O. murgon* (Boat Mtn, Qld.); **H**, *O. penedwardsae* ('Delbessie', Qld); **I**, *O. posticus* (Boolarra, Vic.); **J**, *O. toopi* (Johannsen's Caves, Qld.); **K**, *O. turrbal* (Lamington, S.Qld.); **L**, *O. yackatoon* (Nullamanna, NSW). Scale lines 0.2 mm.

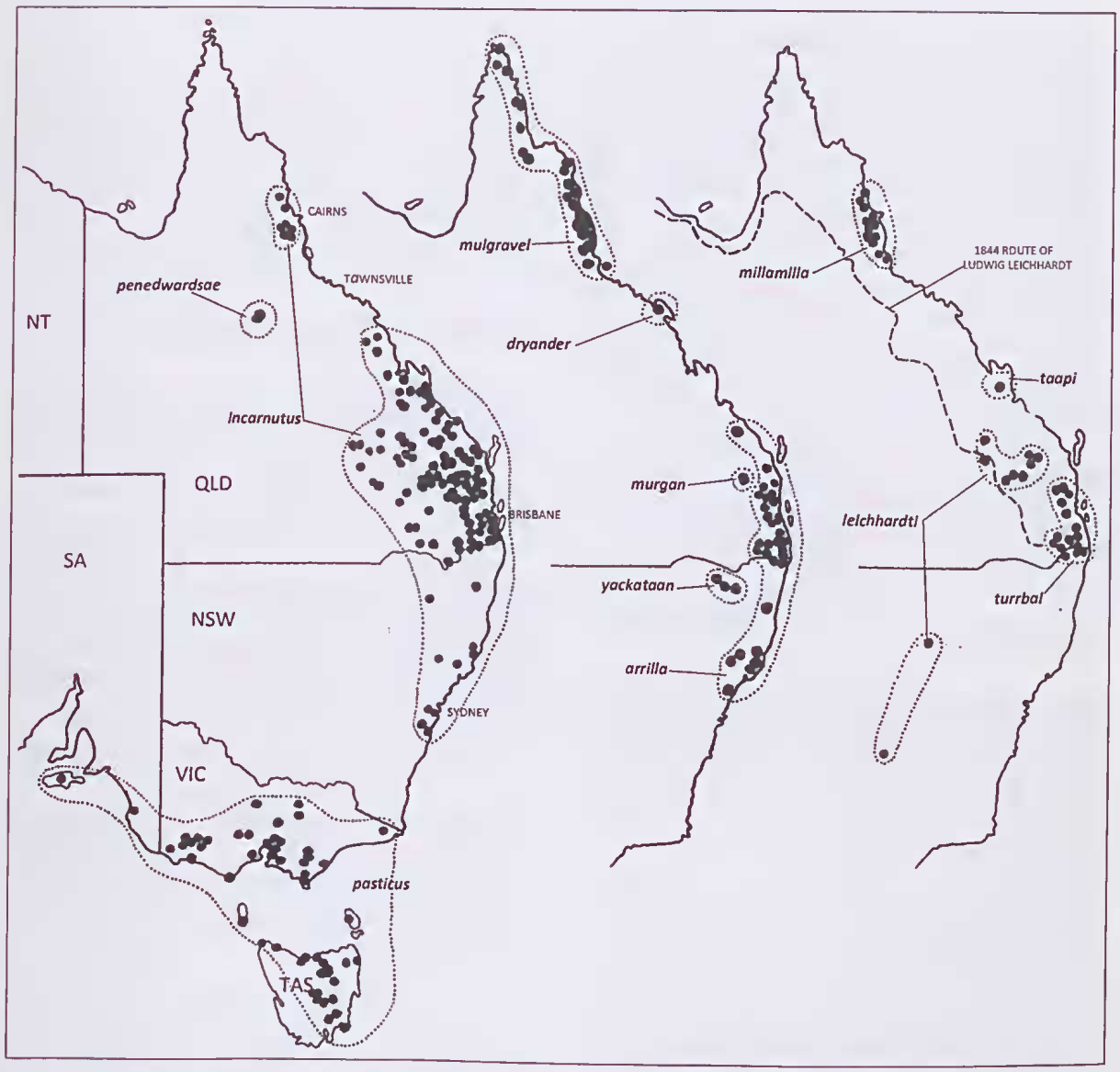

FIG. 8. Distribution maps of all species in the *Onthophagus posticus* species group. The route of the explorer Ludwig Leichhardt is shown.

trap (11♂ 1♀ in QM, QMT178707-18; 2♂ 1♀ in ANIC; 1♂ 1♀ in QDPC).

Description. Predominantly black with a basic pattern of reddish-orange marks on the elytra as follows: short bars on bases of elytral intervals 2, 3, 4, 6, 7, with those of 6 and 7 longer and merging as humeral spots, short bars on sub-apical declivity of intervals 2, 4 & 6, and a narrow strip across the elytral apex. Elytral marks may be reduced to small humeral spots. Pronotum rarely with pale apex and sides. Abdominal venter, pygidium and femora may be pale or have patches of pale colouration. Antennae fuscous. Dorsal surface all sericeus and heavily shagreened. Total length 4.0–4.7 mm.

Male. ***Head.*** Clypeal margin medially deeply bilobed and reflexed, rest of margin almost straight until genal angles, which are roundly

angulate. Clypeal suture with frontal section entirely effaced, lateral portions finely carinate. Frons broadly depressed. Vertex unsculptured. Eyes narrow, 5 facet rows in width, separated by 16 eye widths, canthus incomplete. Surface smooth, shagreened, with fine punctures evenly scattered over entire surface, glabrous except for row of fine setae behind clypeal margin.

Pronotum. Evenly feebly convex, unsculptured. Anterior angles subacute, apices angulate. Hind edge unmargined. Surface smooth, glabrous, entirely shagreened laterally, punctures small, superficial, scattered evenly over entire surface, separated by 2–3 diameters.

Elytra. Intervals flat to feebly convex, smooth, shagreened, with numerous small punctures. Recumbent curved setae present along: entire length of interval 8, apex of intervals 6 and 7 to about 1/4 length of interval, apex of intervals 2, 3, 4 and 5. Striae nitid with small regular punctures. Apex of interval 2 depressed before declivity.

Legs. Fore tibiae elongated, narrowed, inner apical angle bearing a loose brush of long setae, about twice length of spur, distal face of apical tooth also with a tuft of much shorter setae. Inner apical angle of tibia acute and turned downwards. Spur reduced in length, apex turned downwards.

Abdomen. Pygidium convex, shagreened, scattered with small punctures, those on the sides each bearing a curved recumbent seta. Aedeagus as in Fig. 7J.

Female. Clypeal suture complete. Clypeal surface strongly transversely rugose. Punctures larger and deeper in front half of frons. Pronotal surface feebly shagreened all over. Fore tibiae unmodified. Otherwise like male.

Distribution (Fig. 8). Known only from the dry vine forests which grow on the cavernous limestone outcrops which occur within a diameter of about at 6 km near Mt Etna, just north of Rockhampton, central Queensland. There are three discrete limestone/vine forest massifs there: Limestone Ridge, Capricorn Caves and Mt Etna (Sprent 1970). *Onthophagus toopi* has been taken in the first two though trapping has not been undertaken at the third. Specimens were collected using dung baited pitfalls and flight intercept traps.

Comments. *Onthophagus toopi* sp. nov. is similar to *O. incornutus* but differs in being smaller, having more extensive setae on the elytra, in having no tubercles on the male head, and in having the clypeus deeply bilobed. *O. incornutus* also occurs at Mt Etna. Like *O. unrgou*, *O. toopi* is quite variable in its colour pattern. It has been referred to as *Onthophagus CQ6*.

Onthophagus turrbal Matthews, 1972
(Figs 7K, 8)

Distribution (Fig. 8). See discussion of the distribution and taxonomic realignment of this species and *O. millamilla* under treatment of the latter. Storey (1974) recorded *O. turrbal* from Tooloom and Yabra SF (NSW) and Mary Cairncross Park (Qld), while Williams (2002) recorded it from Cambridge Plateau and other sites in far northern NSW. Present material shows the southern population extends from Terania Creek and Whian Whian (AM) in the south, west along the Border Ranges to Bald Mountain (QM) and north to the Jimna and Conondale Range (QM). The aedeagus is shown in Fig 7K.

Onthophagus yackatoon Storey & Weir, 1990
(Fig. 1F, 7L, 8)

Distribution (Fig. 8). All records for this species are within a diameter of about 50 km near Inverell, NSW, and the only new locality since its description is from nearby Nullamanna (AM). The aedeagus is shown in Fig. 7L.

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